

## **Participation in Kernel Blitz 2001 VSW MCM AUV Trials**

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### **LONG-TERM GOALS**

- Collaborative development of key Autonomous Underwater Vehicle technologies in support of future naval capabilities, esp. shallow water and very shallow water mine counter measures.

### **OBJECTIVES**

- Post processing Morpheus and OEX sonar and video data products within SeeTrak to auto identify relevant targets then export to MEDAL.
- Interaction with relevant Naval MCM ops personnel to better understand their field requirements.
- Deployments with AUV Morpheus from del Mar boat basin
- Participation and exhibit at Distinguished Visitor day
- Possible deployments with OEX AUV on board RV New Horizon if berths available.

### **APPROACH**

Personnel as listed above.

SeeByte Ltd. participation in these trials assists our overall collaborative effort with FAU, WHOI and ONR in support of FNC and VSW MCM in particular.

The travel funds enable leverage of results/experience by Heriot-Watt University Ocean Systems Laboratory in EU and UK funded programmes, to establish opportunities and benchmark state of the art.

## TRAVEL COMPLETED

**Table 1. Summary of visits conducted under this VSP.**

Person Visited	Position	Institution / Conference	Location	Purpose	Dates (mm/dd/yy format)
Dr Tom Swean, Dr Doug Toderoff Mr Bill Schopfel	Code 320E  OMCM FNC Program Manager HeadMFL M&S Office	ONR	Camp Pendleton, San Deigo, Ca.	Participation in Kernel Blitz '01 trials and demos	10-18 March '01
Dr. Jim Bellingham	Director of Engineering	MBARI	Monterey, Ca.	AOSN Collaboration	19 <sup>th</sup> March '01
Dr Don Brutzmam	Professor	Naval Postgraduate School	Monterey Ca	MEDAL and Hardware-in Loop Collab.	20 <sup>th</sup> March '01
Dr. Steve Rock	Professor	Stanford University	San Francisco	Collaboration on AUV visual navigation, servoing and mosaicing	21 <sup>st</sup> March '01

## RESULTS

- The team successfully gathered video containing mine and mine-like targets from the Morpheus AUV
- SeeTrak was successfully used to automatically detect the mines and visualise them within its georeferenced display. The visibility conditions were moderate to poor, showing the utility of the CAD algorithms employed.
- The team participated in the Distinguished Visitor day. SeeTrak was well received by warriors and commanders.
- The early withdrawal of the Florida Atlantic University Ocean Explorer and Morpheus vehicles limited the opportunities for further work during the second week. No berths were available for teaming with BP-AUV on R/V New Horizon. Visits were therefore programmed to relevant local research groups to gain maximum benefit from travel and committed expenditure.
- A visit to Dr. Jim Bellingham, Director of Engineering at MBARI, have further highlighted collaboration opportunities pursuing AOSN concepts.
- A visit to Dr Don Brutzmam, Naval Postgraduate School. Monterey Ca. allowed further discussion on MEDAL, and hardware-in-the-loop/3D visualisation for AUV development.
- A visit to Dr. Steve Rock, Stanford University Dept. Aeronautics and Astronautics will allow comparison and benchmarking of our visual control, navigation and mosaicing methods for AUV applications.

## IMPACT/APPLICATIONS

- VSW-DET Seals currently procuring SHARV AUV's for evaluation showed strong interest in SeeTrak. Intent expressed to pursue further evaluations and make valuable user feedback.
- Invitation and intent to fund expressed for participation at AUV-fest, Gulfport, November 2001
- Numerous inquiries from various naval branches about possible procurement of SeeTrak for other applications.
- Further successful demo of computer aided mine detection in video data.
- 3 Invitations to collaborate in proposals to BAA-01-012, deadline July 2001.

## TRANSITIONS

- Future demonstrations at ONR sponsored AUV trials, hopefully leading to fleet transition of SeeTrak technologies. Interest from VSW Det amongst others.
- Opportunity for extended trial/collaboration with other ONR funded AUV programs (Remus, Cetus et al).

## RELATED PROJECTS

The ONR funded AUV and sonar effort at FAU is paralleled by the following selected UK and European Projects. These projects are similarly relevant to other ONR funded AUV programs at WHOI, Boeing, Lockheed, Bluefin et al.

2001/2004 EU Framework V Environment Program  
*AMASON – Advanced Mapping with Sonar and Video*  
Contract no: EVK3-2001-00067

2001-2003 EU Framework V Growth Program  
*AUTOTRACKER: Automatic Pipeline and Cable Tracking with an AUV*  
Contract no: G3RD CT2000 00265

2001-2003 EU Framework V Growth Program  
*ALIVE: Autonomous Light Intervention Vehicle (Autonomous docking and intervention)*  
Contract no: G3RD-CT-2000-00269

1997/00 Commission of the European Communities, DG X11, MAST III  
*ARAMIS: Advanced Robotic Technologies for Autonomous Mobile Investigation of Benthic Stations"*  
Contract no: MAS3-CT97-0083

1997/00 Commission of the European Communities, DG X11, MAST III  
*AMADEUS: Advanced Manipulation for Deep Underwater Sampling*  
Contract No: MAS3-CT97-00

1997/99 UK Engineering and Physical Sciences Research Council  
*"FLAPS: Flexible Actuators for Positioning and Stabilisation"*  
Contract No: GR/L29217

1997/99 EPSRC /Lockheed/DERA/Halliburton/Tritech/Slingsby Eng.

## SELECTED RELEVANT RECENT PUBLICATIONS

1. M.Sfakiotakis, D.M. Lane, J.B.C. Davies "Review of Fish Swimming Modes for Aquatic Locomotion" IEEE Journal of Oceanic Engineering, April 1999 24 (2).
2. I. Tena Ruiz, D.M.Lane, M.J.Chantler, "Robustness Investigation of Object Classification in Sector Scan Sonar Image Sequences Using Inter-Frame Features" IEEE Journal Oceanic Engineering, v24 no 4 pp 458-469 October 1999.
3. E. Trucco, Y. Petillot, I. Tena Ruiz, C. Plakas, D. M. Lane "Feature Tracking in Video and Sonar Subsea Sequences, With Applications" Computer Vision and Image Understanding International Journal 79, pp92-122, 2000
4. Yongji Wang, David M. Lane, Gavin J. Falconer "Two novel approaches for unmanned underwater vehicle path planning: constrained optimisation and semi-infinite constrained optimisation" Robotica (2000) Vol 18 pp123-142
5. Y. Wang, D.M. Lane, "Robot Motion Planning Using Constrained Optimisation with AND/OR Relationships and Constructive Solid Geometry" IEEE Transactions on Systems Man & Cybernetics, Volume 30 No 4 November 2000 pp525-536
6. Y. Petillot, I. Tena Ruiz, D.M.Lane "Underwater Vehicle Obstacle Avoidance and Path Planning Using a Multi-Beam Forward Looking Sonar" Forthcoming IEEE Journal Oceanic Engineering, 2001. Joint Author
7. K. Lebart, E. Trucco, D.M. Lane "Real-Time Automatic Sea Floor Change Detection from Video". Proc IEEE Int Conf. OCEANS 2000. Rhode Island Convention Centre, USA. 11-14 Sept 00.
8. A. Almos, E. Trucco, D.M.Lane "Detecting Ripple Patterns in Mission Videos " Proc IEEE Int Conf. OCEANS 2000. Rhode Island Convention Centre, USA. 11-14 Sept 00.
9. D.M. Lane, E. Trucco, Y. Petillot, K. Lebart, I Tena Ruiz "New developments in embedded sonar and video processing for AUVs". Society for Underwater Technology Symposium and Showcase on Unmanned Underwater Vehicles, Southampton Oceanography Centre, 27-28 September 2000.
10. J.-F. Lots, D. M. Lane, E. Trucco F. Chaumette "A 2-D visual servoing technique for underwater vehicle station keeping" IEEE International Conference on Robotics & Automation, May 2001, Seoul, Korea
11. I. Tena Ruiz, Y. Petillot, D.M. Lane C. Salson "Feature Extraction and Data Association for AUV Concurrent Mapping and Localisation" IEEE International Conference on Robotics & Automation, May 2001, Seoul, Korea
12. K Hamilton, D.M. Lane, N.K.Taylor. K.E. Brown "Fault Diagnosis on Autonomous Robotic Vehicles with RECOVERY: An Integrated Heterogeneous-Knowledge Approach" IEEE International Conference on Robotics & Automation, May 2001, Seoul, Korea

13. M.Sfakiotakis, D.M. Lane, J.B.C. Davies “*An Experimental Undulating Fin Device Using the Parallel Bellows Actuator*”. IEEE International Conference on Robotics & Automation, May 2001, Seoul, Korea
14. D.M.Lane, G.J. Falconer, G. Randall “*Interoperability and Synchronisation of Distributed Hardware-in-the-Loop Simulation for Underwater Robot Development: Issues and Experiments*” IEEE International Conference on Robotics & Automation, May 2001, Seoul, Korea
15. D.M. Lane “*Embedded Sonar and Video Processing For Autonomous Underwater Vehicles - Commercial, Military & Marine Science Applications*” Tutorial/Workshop on Subsea Robotics. IEEE International Conference on Robotics & Automation, May 2001, Seoul, Korea